2002 Evaluation of Interconnections with Molten Salt HTF in a Trough SF

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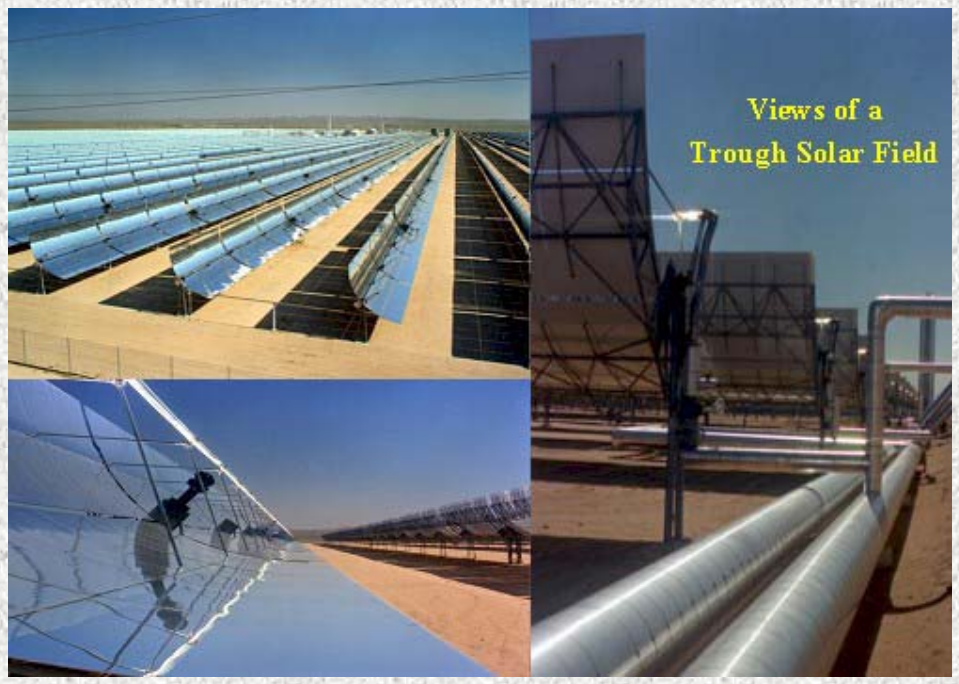
Scope

- Nitrate salts oxidize graphite packing materials at temperatures above about 350C
- This effort examined solutions including a new packing material or a design alternative
- Review of current ball joint design to reduce the torque required to turn the ball joint and to further reduce leakage.

- **Candidates**
  - o **Ball joints**
  - o **Flex hoses**
  - o **Swivel joints**
- **Seals and Packing**
  - **Ball joint seals remain a key issue**
- **Most Promising Options**



Design Requirements

Salt: **Calcium nitrate eutectic (HiTecXL)**

Temperatures Inlet: 290C Outlet: 450/500C

Pressures, bar (approx.)

Ball joint	Inlet: 11	Outlet: 7
Flex hose	Inlet: 14-21	Outlet: 7
KJ VP-1	Inlet: 41	Outlet: 15

Required displacements and lifetime

- 210-degrees rotation of HCE about 56.5-inch radius (-30 to 180 and return, daily)
- ±8 inches thermal displacement of HCE end along its axis (using LS-3 length)
- ±2 inches thermal displacement of crossover pipe end along its axis

Thermal insulation

Suitable for 500 C pipe temperature

Limit outer skin to 70 C

Materials

Austenitic stainless steels, or >9% Cr-Mo steel, or demonstrated compatibility with Hitec XL salt at 500 C.

Ball Joint Packing

- Graphite seal incompatible with molten salt
- Manufacturers did not generally believe a leak-tight seal for use with high-temperature molten nitrate salt was feasible, especially metal seal
- One manufacturer suggested that a ceramic seal in a rotary joint might work

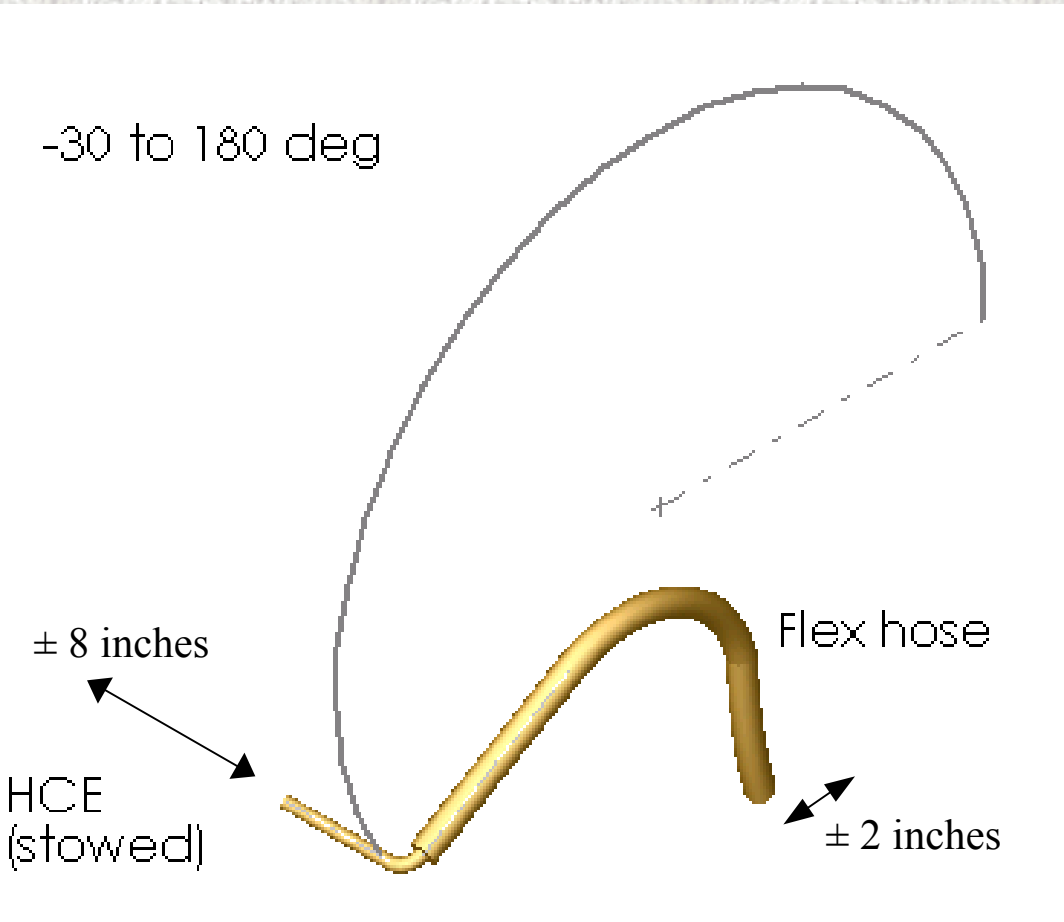
Alternative Ball Joint Packing

- Bench test carried out with diffusion-bonded hexagonal boron nitride and HitecXL at 500 C. Boron nitride has resiliency and lubricating characteristics analogous to graphite (due to hexagonal platelet structure). After 12 days, the sample appeared to have changed very little. Weight change was +1.8%. Material was still essentially all boron nitride.
- An additional 12-day test at 565C with solar salt (60:40 wt. % $NaNO_3$:KNO_3) produced noticeable smoothing of cleaved surfaces, and a weight change of –10%. These results suggest a pronounced change in kinetics between 500C and 565C.

Alternative BJ Packing (cont)

- For trough interconnect conditions, the results are encouraging enough to warrant further testing in a seal configuration.
- By no means clear that the mechanical properties of boron nitride make it a suitable sealant, even if it is chemically compatible with molten nitrate salts below some temperature.
- Continued testing required

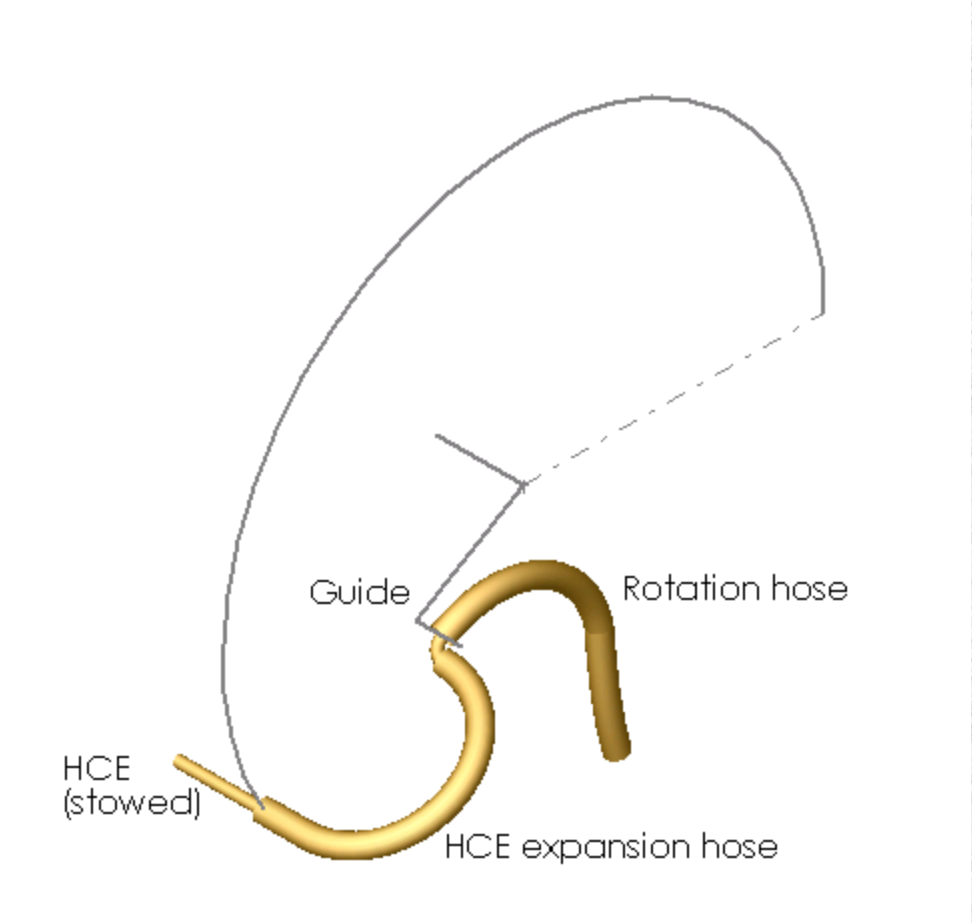
Standard Flex Hose Configuration



Interconnect geometry, showing displacements that must be accom-modated (±2 inches is at loop-end crossover pipes only). The figure also illustrates the single -hose option, and the origin of its torque in the HCE's expansion.

This configuration is problematic, because of the fatigue-inducing torque imposed on the flex hose by the expansion of the HCE.

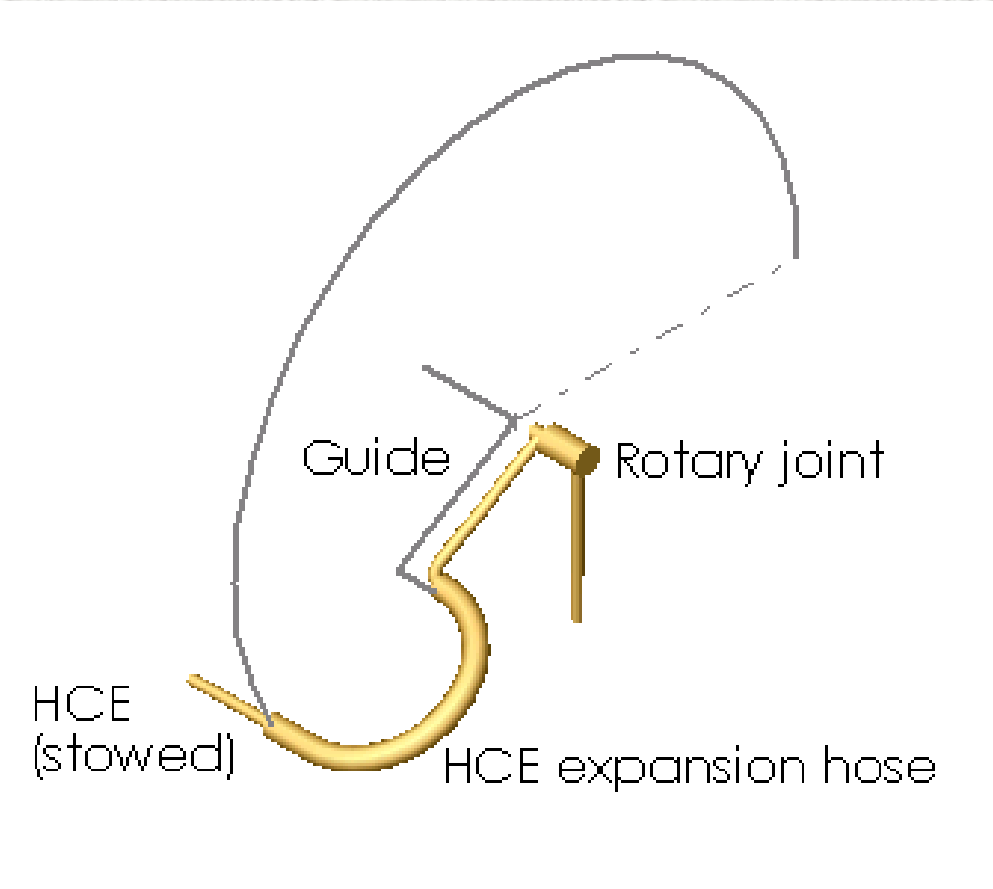
Alternative Flex Hose Configuration



Two-hose reduced-torque interconnect. The guide, driven by the SCA, would include a support system (not shown) for the HCE expansion hose.

This configuration that eliminates the HCE expansion torque, increasing durability.

Rotary joint – hose interconnect



The guide, driven by the SCA, would include a support system (not shown) for the HCE expansion hose. Turning torque low.

Requires conventionally configured ceramic seal at rotary joint (alumina, zirconia-toughened alumina, yttria-stabilized zirconia, or silicon carbide). Compatibility screening tests are favorable.

Lifetime of the swivel joint/flex-hose combination will depend primarily on (a) fracture of the ceramic seal, and (b) fatigue failure of the flex hose.